FLYWHEEL PUTS RAIL INTO RACING MODE

FORMULA ONE TECHNOLOGY IS OFFERING TRAINS A BOOST. AN ELECTROMECHANICAL, COMPOSITE FLYWHEEL, DEVELOPED BY WILLIAMS HYBRID POWER (WHP), PROMISES FLEETS A HIGH-POWER, COST-EFFECTIVE, AND ENVIRONMENTALLY FRIENDLY SOLUTION FOR MOBILE OR STATIONARY ENERGY RECOVERY AND STORAGE.

The company's first application of the technology was in the tough environment of Formula One racing. Through development of a flywheel for Williams F1's Kinetic Energy Recovery System (KERS), WHP is confident it has proved its engineering capabilities in the composite flywheel field, as well as improving aspects of the technology in the process.

Building on the racing project, WHP is now making the technology available to meet high-power energy storage needs in a variety of applications, which include hybrid passenger vehicles and buses, rapid transit systems, light rail, and electric trains. "From a power-density point of view, the flywheel is better than the battery; from an energy density view, batteries are better than the flywheel," says Ian Foley, managing director, WHP. "The flywheel technology is ideal for vehicles with regular starts and stops," he adds. "Because although the energy storage period is shorter, buses and trains typically use energy within a shorter period of time, plus it is released more quickly."

The flywheel serves as a reservoir for storing the energy recovered by the KERS in mechanical form. With an electrical, rather than a mechanical connection to the motor, it delivers a higher energy yield of around 95%, compared to 60%, due to fewer losses. For electrically connected flywheels, this loss typically occurs in the electronics, e.g. the windings; for the mechanical, via friction and in the gearboxes. Meanwhile the 100% composite (carbon and glass fibre) rotor delivers various benefits, which include the ability to be continuously deep-cycled at high power with no impact on performance or a reduction in life cycle, as well as improved safety: in the event of a failure, there are no metallic fragments requiring containment.

TESTING TIME

Two of the flywheel storage systems have already been put to the rail test at Bombardier's 1.88km test track in Kingston, Ontario (Canada). Characteristics of the units studied over four weeks in 2011 included energy savings, emergency reserve, and voltage support. The single car test train was pro-

This year's 80th edition of the *24 Heures du Mans* sports race in France was won by the Audi R18 e-Tron Quattro, with a supporting role by WHP's electric flywheel technology. In the process, the car also made history as the first hybrid-powered vehicle to finish on the podium.

Williams Hybrid Power designed an entirely new, ultra-lightweight electric flywheel and associated power electronics to ensure its solution outpaced other potential technologies such as batteries, ultra-capacitors, or mechanical flywheels when fitting the car. "Our flywheel technology started its life as a motorsport application," commented Ian Foley, managing director of WHP, "and whilst it's since been adapted for a variety of other purposes, motorsport will always be close to our heart, and is the ultimate proving ground for our technology."

pelled and braked using a single (instead of two) Linear Induction Motor. The positive results released include the following:

- the flywheels were able to capture, store, and regenerate 100% of the available braking energy, resulting in energy savings of between 2 to 16%. And this despite limiting factors such as the mass of the single car train, the single LIM, train windage and rolling losses, and the lack of train regenerating power at speeds below 20km/hr
- furthermore, they powered the train at 60km/hr for 1,364 metres using stored flywheel energy only. And the track voltage increased by over 10Vdc during acceleration of the train, thanks to the flywheels supplying up to 75% of the required current.

IN THE WIDER FIELD

For markets like India, China, and the Middle East, Williams sees the flywheel as an integral part of new and 'smarter' rolling stock. While for other markets with fleets already in service, retrofitting the technology is the solution. "When making the case for the flywheel, you really have to consider the major benefits of energy savings over the years," insists Doug MacLennan, sales & marketing manager, Williams Technology Centre, Qatar. And a further benefit of the retrofit to bear in mind, he told EURAILmag, is the potential savings to be made when it comes to investment in infrastructure: "Since more and more rolling stock is being upgraded, if the electrical infrastructure is not also upgraded to stay in line, the system-level voltage is not maintained. But with the flywheel technology, it is."

Aware of the costs involved for manufacturers when introducing new technology, which leads to more expensive end products, "push-pull" is how Mr MacLennan describes the current market situation. "We are seeing pull, i.e. demand, from end users saying 'we want this,' while the push needs to come from Original Equipment Manufacturers such as ABB in Switzerland and Schneider Electrics in France, together with constructors like Bombardier, Alstom, and Siemens ■"

Lesley Brown

All photos ©Williams Hybrid Power

Thursday, January 17, 2013

New technology planned for Alstom Citadis LRVs

Written by Douglas John Bowen

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Alstom Transport/R. Vilalta

Alstom and Williams Hybrid Power Thursday announced they have signed an agreement to apply Williams Hybrid Power's energy storage technology to Alstom's Citadis light rail transit (LRT) vehicles by 2014.

The two companies companies will "work together to adapt and develop an energy storage solution that has the potential to reduce the greenhouse gas emissions of Alstom's rolling stock."

Originally developed for the 2009 Williams Formula One car, Williams Hybrid Power's energy storage technology has since been introduced into applications such as London buses. The companies say the technology offers fuel savings and emissions reductions by harvesting the energy that is normally lost as heat when braking and turning it into additional power. "It is ideally suited to trams [LRT vehicles] because of their stop-start nature and high mass. Furthermore, the flywheel's rotor is made of composite material which is inherently safe because there is no metallic structure travelling at very high speed," the two companies said.

"As a world leader in rail transport technology, Alstom is continuously looking to challenge and improve the energy efficiency of its trains," said Alstom Transport Innovation Director Dominique Jamet. "We are proud to announce the collaborative project with Williams Hybrid Power that aims to deliver an innovative solution that does not only save energy but also re-use it to add more power to the tram while reducing energy use and CO2 emissions."

Ian Foley, Managing Director of Williams Hybrid Power Managing Director Ian Foley said, "From the very beginning we highlighted trams as an ideal application for our technology and to be collaborating with the market leader on this project is very exciting. We both share a common goal – developing the next generation of green transport technologies – and this agreement will hopefully prove pivotal in finding a solution that not only cuts carbon emissions but crucially cuts costs for the end user.'

Tagged under Alstom Light Rail

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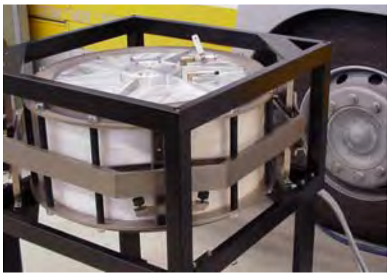
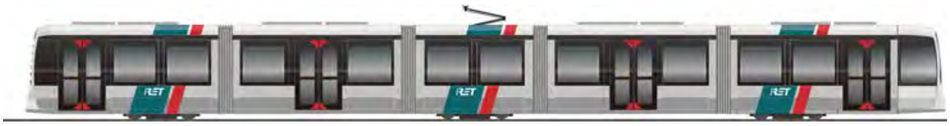
Citadis Rotterdam as Flywheel Demonstrator





CITADIS with flywheel:

The CITADIS is a modern, fully low floor tram of Alstom. For test & demonstration a CCM flywheel system has been installed on CITADIS roof. The CCM flywheel offers CITADIS capabilities as: “Autonomy Mode” (wireless tram) and “Economy Mode” (energy recovery and less heavily loading of energy supply infrastructure).

Results of tests:

- The vehicle can be operated as a normal CITADIS
- In “Autonomy Mode” the vehicle (40 tons) has shown the following results:
  - 2,000 m running distance without overhead wire
  - the vehicle can run up to 50 km/h on flywheel power
  - the Erasmus bridge (Length 900 m; Height 15m) in Rotterdam is crossed in “Autonomous Mode”
  - covering 3 stops before re-charging is required
- The “Economy Mode” is under test now. The flywheel system will recover brake energy and less heavily load the energy supply infrastructure

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Flywheels as High Power Storage Devices for Mobile Applications

IRES-I Conference

Gelsenkirchen, 30-31 Oct. 2006

Dr. Frans Thoolen

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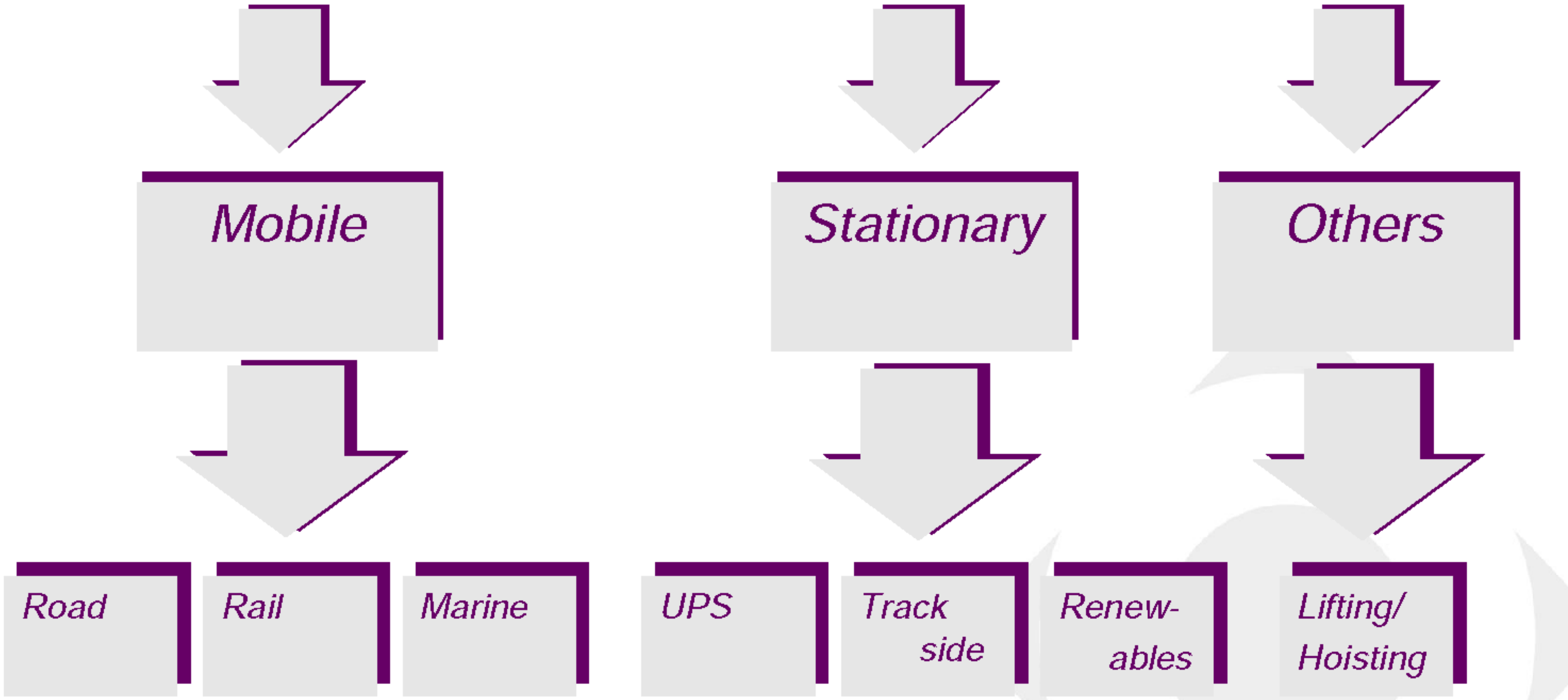
Vehicle Speed
Power Demand
Average Power
Time

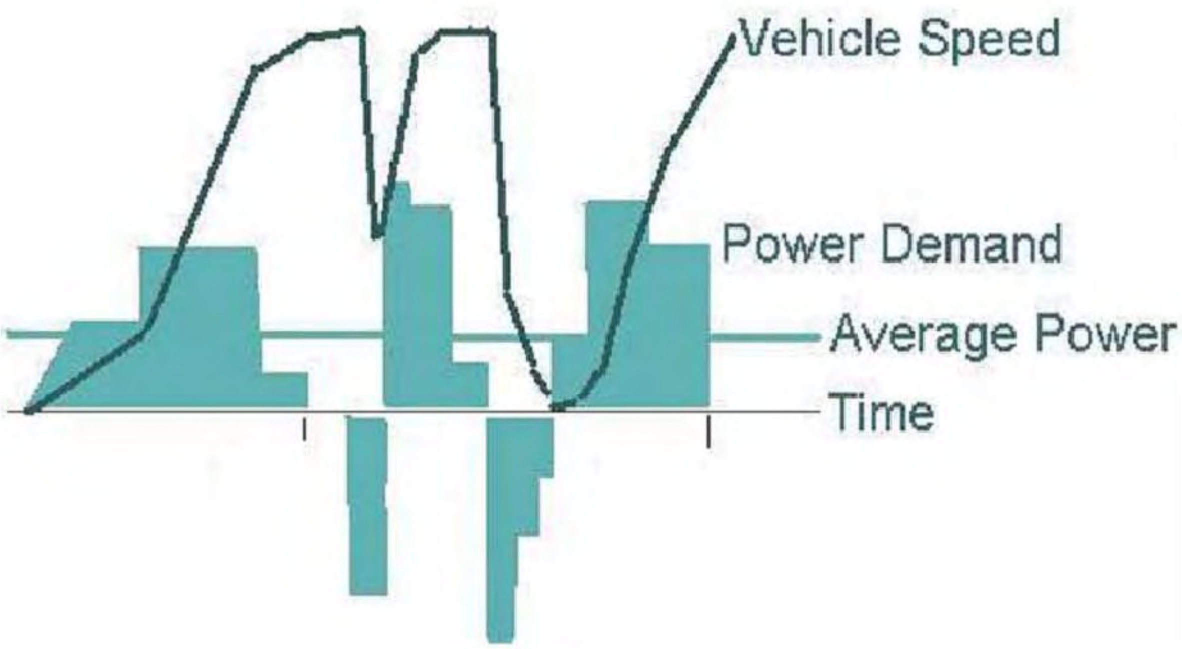
Applications

Peak Power Shaving



Peak Power Shaving

Typical urban drive cycle



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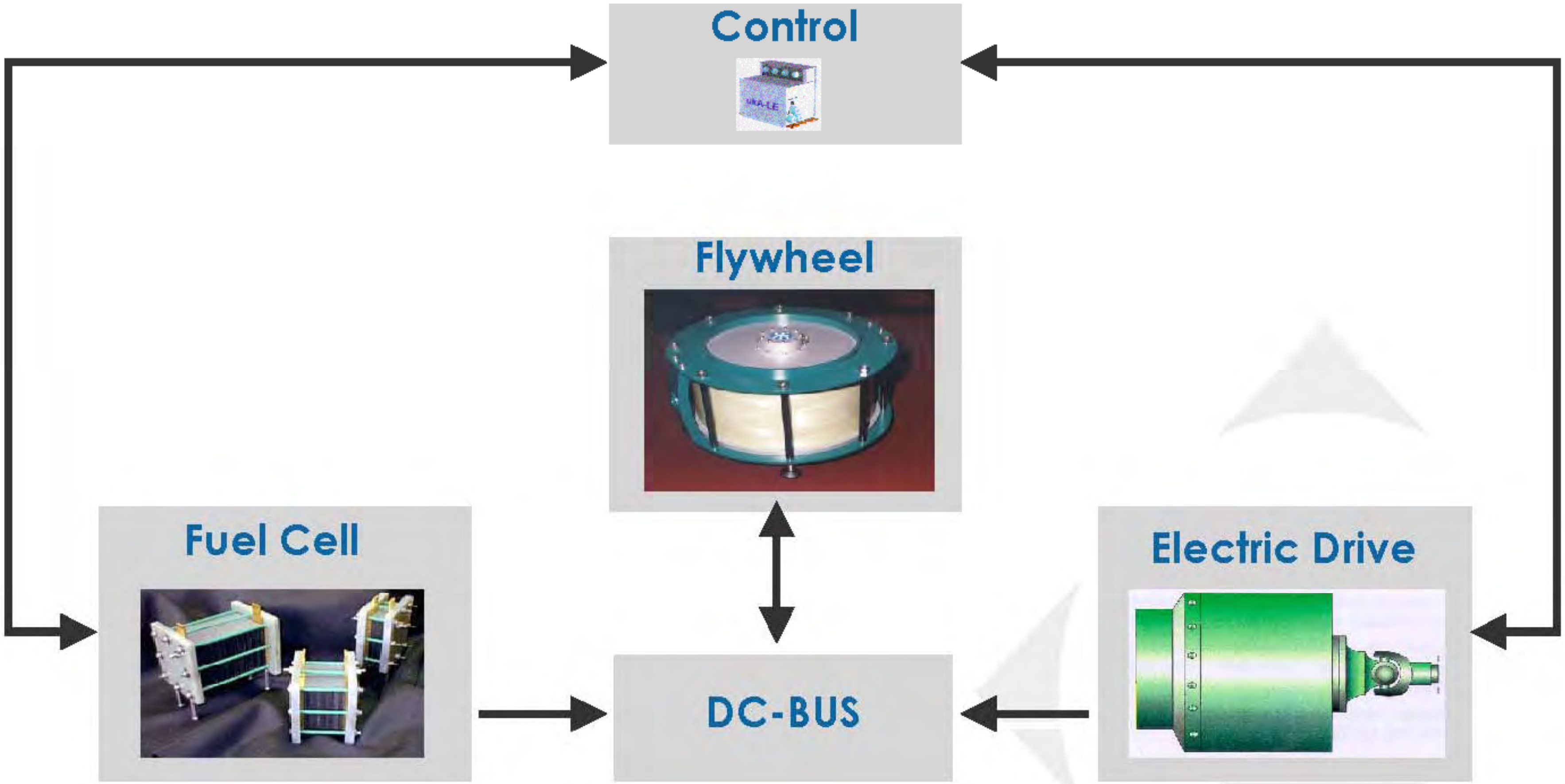
Modular Drive System



Storage Technologies

	Power	Energy	Cycle life	Chemi-cals	Typical Load cycle times
Super Capacitor	++	-	+	*Yes*	*Seconds*
Battery	-	++	-	*Yes*	*Minutes to hours*
Flywheel	+	+	++	*No*	*Seconds to minutes*

Different load requirements call for different storage technologies

Flywheel Energy Density

Energy storage
$E = \frac{1}{2} . J . \Omega^2$

Power
$P = T . \Omega$

	Steel flywheel	Carbon flywheel
J (inertia)	*1*	*1/3*
Ω (rotation speed)	*1*	*4*
E (energy storage)	*1*	***>5***

Flywheel safety

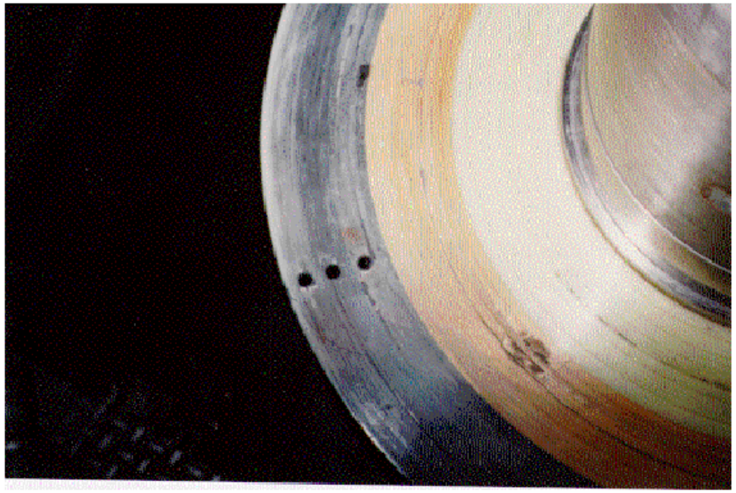
Passive Safety

- Fail-safe rotor
- Ceramic bearings
- Robust containment
- Collision-proof frame

Active Safety

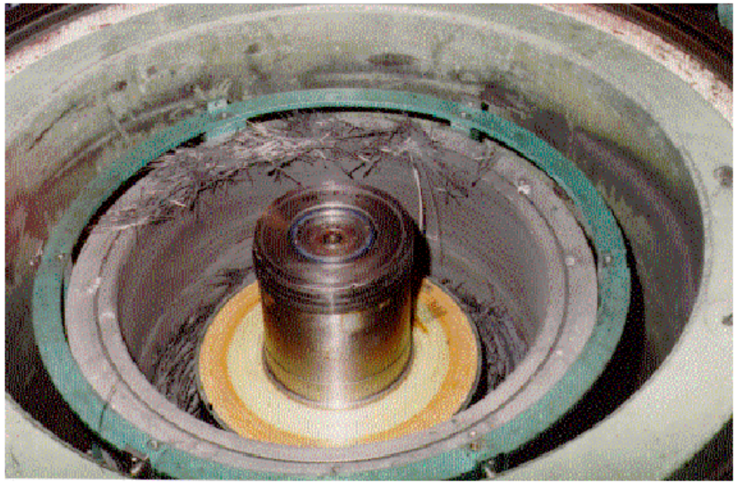
- Guarding :
  - temperature
  - speed
  - vibrations
  - current
- Automatic shut-down above alarm levels

Flywheel safety tests



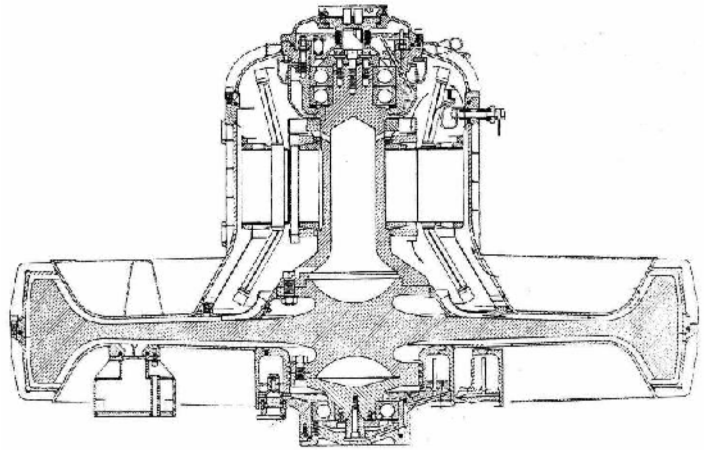
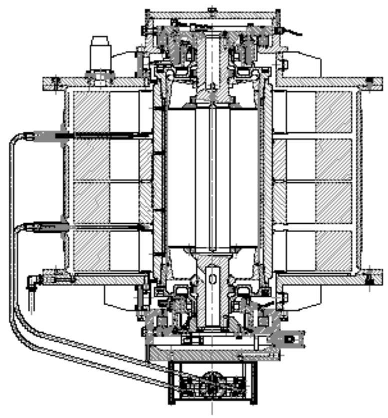
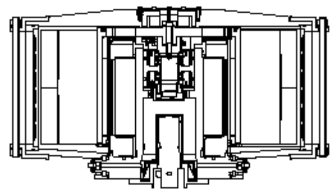
Rotor failure

Containment qualification



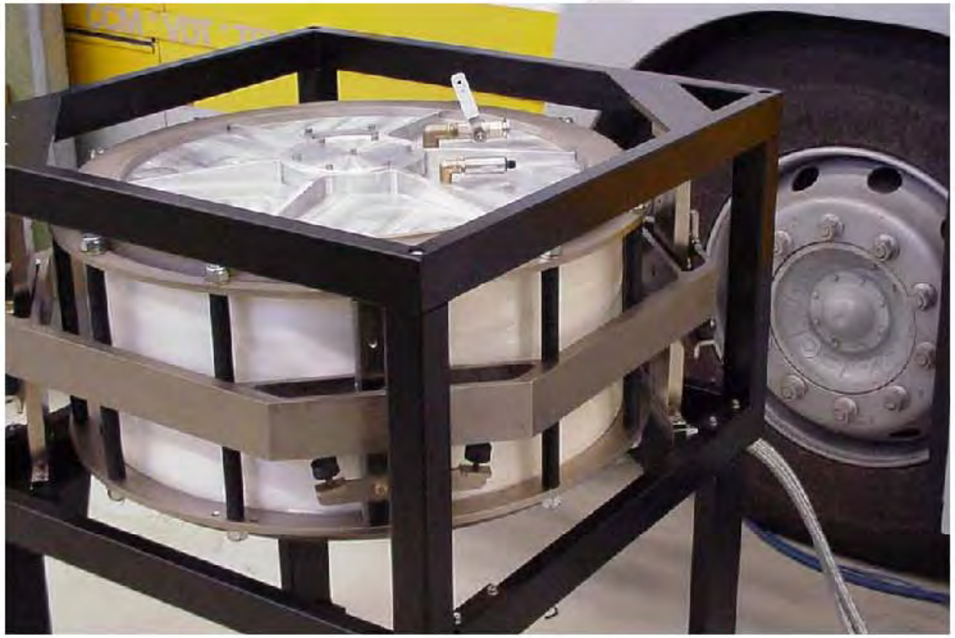
Flywheel history

Flywheel miniaturization

1955 Oerlikon	1995 CCM	2004 CCM
		
3.13 kWh / 130 kW	4 kWh / 300 kW	4 kWh / 300 kW
3,000 rpm	15,000 rpm	22,000 rpm
Ø1700 x 1100 mm	Ø900 x 900 mm	Ø780 x 450 mm
3000 kg	850 kg	375 kg

Modular Concept

- Fully integrated high power Permanent Magnet Motor/Generator
- High speed carbon fiber flywheel
- Compact bearing module
- Vacuum/safety containment

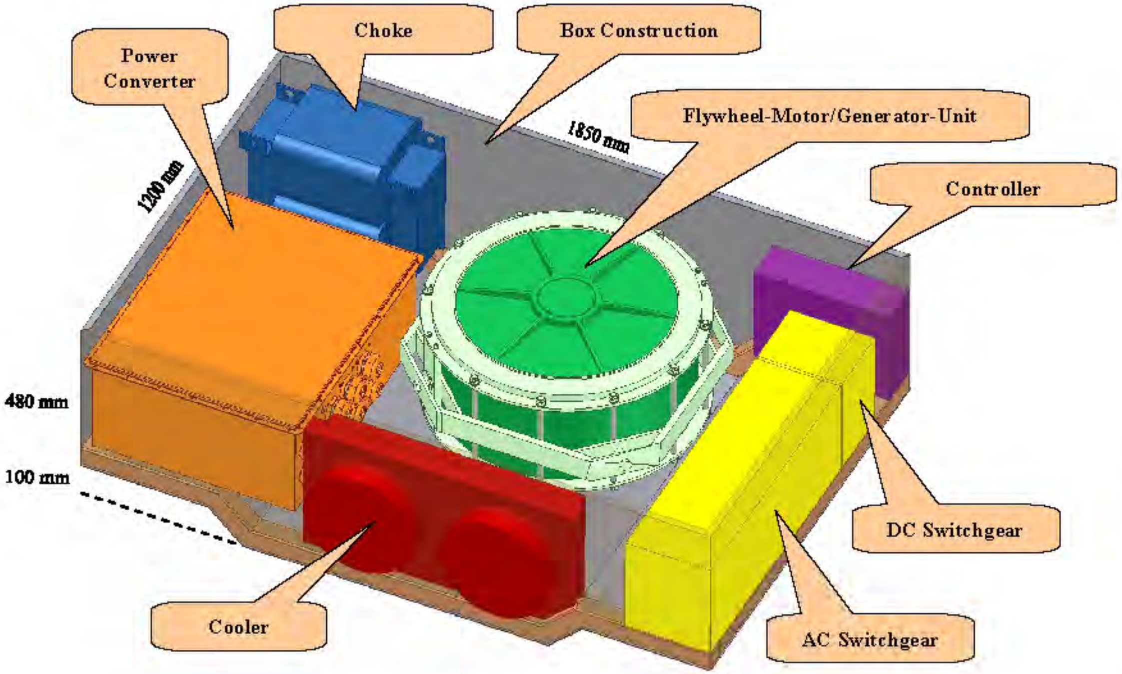


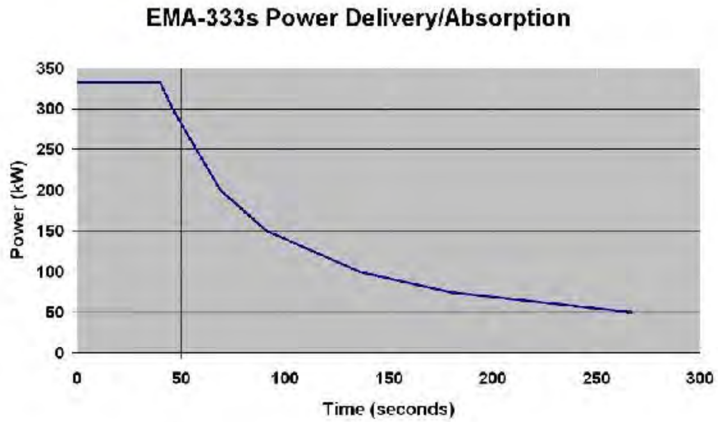
Product Portfolio Mobile

Type	Application	Status
RxV- 0 FMG*: Ø300x225[mm];28[kg] 50kW during 25 sec **About 0.33 kWh effective**	Passenger Cars (<1.5 tons)	Future Development
RxV- I FMG*: Ø600x450[mm];225[kg] 150kW during 50 sec **About 2 kWh effective**	Light-weight vehicles (<15 tons)	Under progress
RxV- II FMG*: Ø780x450[mm];375[kg] 300kW during 50 sec **About 4 kWh effective**	Medium-weight vehicles (15~30 tons)	Dedicated Project applications
RxV- III FMG*: Ø950x650[mm];875[kg] 750kW during 50 sec **About 10 kWh effective**	Heavy-weight vehicles (>30 tons)	Future Development

EMAFER RxV-II Data

Layout Example





L x W x H = 1100 x 2000 x 550 mm

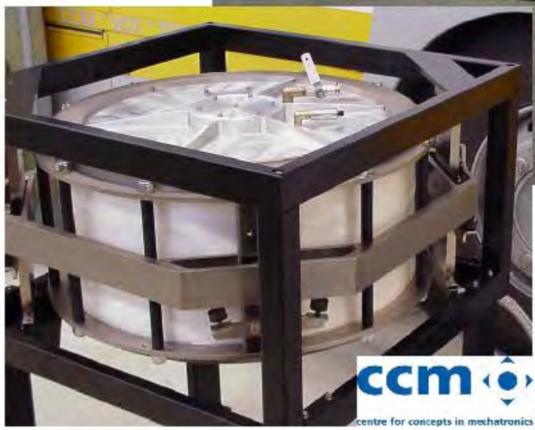
Mass = 1100 kg

Power (kW)	Time (s)
333	40
300	46
200	69
150	91
100	136
75	180
50	267

Citadis with flywheel installed on the roof

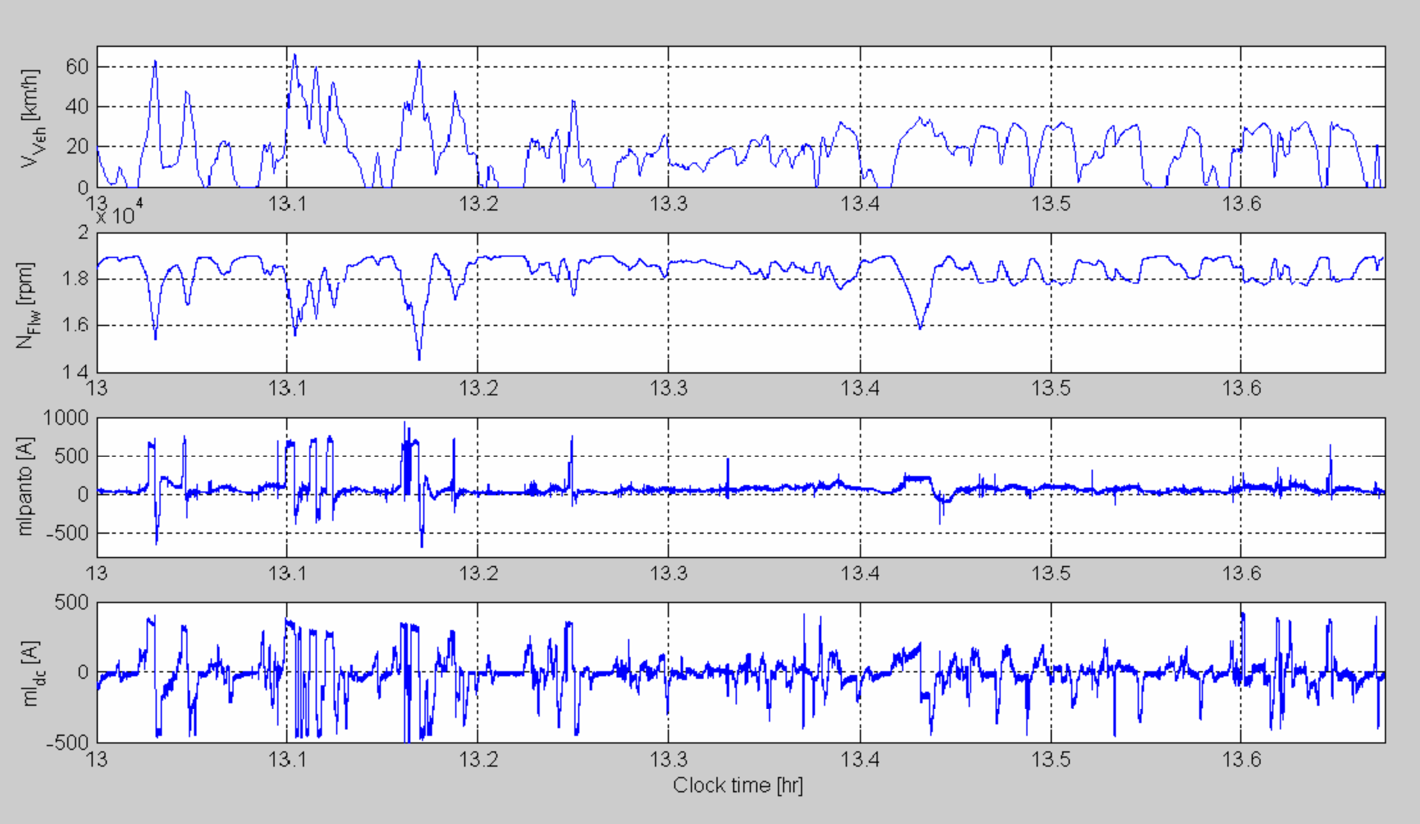
Recent Projects

Fraunhofer AutoTram



Maja Stuwadoors: Floating Grab Crane

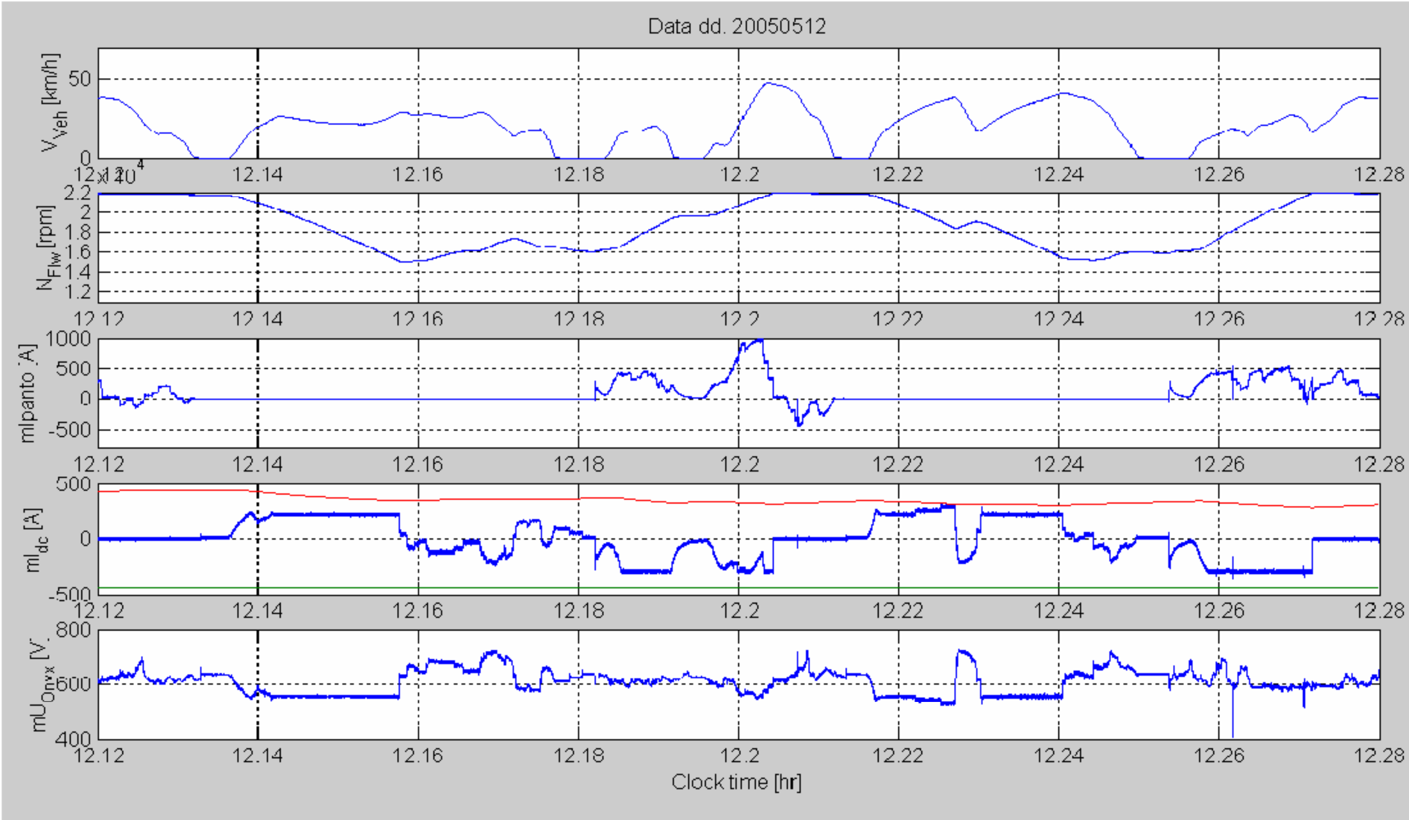
Results: Flywheel tram Eco-mode



$I_{driveRMS}$=243 A ; $I_{pantoRMS}$=198 A

→ 39.2% reduction in line current

Results: Flywheel tram Autonomous-mode



Crossing the Erasmus bridge:

Several minutes ride without overhead

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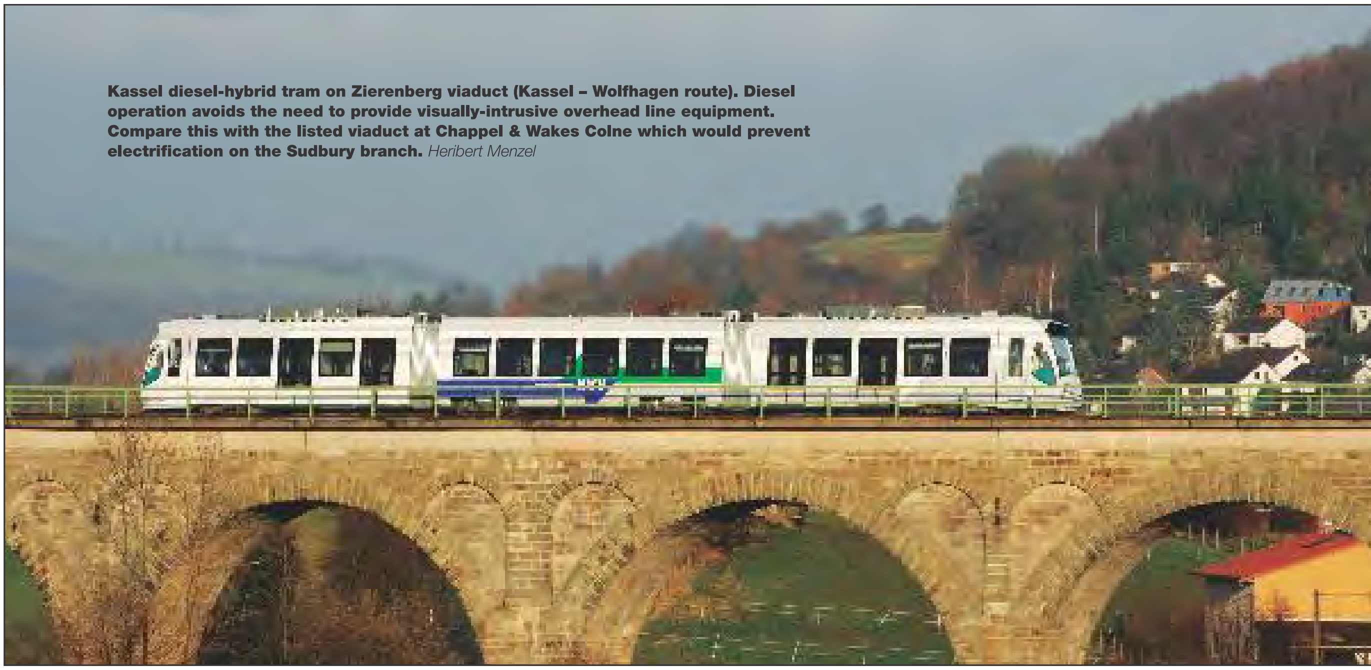

Kassel diesel-hybrid tram on Zierenberg viaduct (Kassel – Wolfhagen route). Diesel operation avoids the need to provide visually-intrusive overhead line equipment. Compare this with the listed viaduct at Chappel & Wakes Colne which would prevent electrification on the Sudbury branch. *Heribert Menzel*

Diesel trams: a new way forward?

Charles King suggests a novel approach for secondary routes

Light rail technologies have received closer attention in recent times as potential solutions to transport problems as well as providing alternatives to 'traditional' railway operation. In light of this, a trip run by ACoRP (Association of Community Rail Partnerships), and organised by Faber Maunsell, took eight delegates from Network Rail, the Department for Transport and Transport Scotland in December last year to Switzerland and Germany. The aim of this was to study developments in light rail and their applicability to the UK.

A major focus of this trip was 'tram-train'. For many people, this concept is most closely associated with the city of Karlsruhe in south-west Germany, which pioneered the technology in the 1990s. Essentially it involves the 'joining-up' of a tram network with heavy rail so that local services sharing paths with conventional trains on the main line can travel over both systems, enabling seamless through journeys. The need to change modes is thereby eliminated: accessibility is improved and end-to-end journey times drop. In Karlsruhe's case, the city centre, about two km from the main station, was the main attraction, and a through journey from the suburbs with dual-voltage electric trams was made possible.

Factors for success

Karlsruhe's success has led to numerous developments and extensions, most recently conversion of the 30-km long Murgtalbahn to tram-train operation, which took only seven years from conception to completion at a cost of Euro75million (£50million). The longest possible journey on the system now takes in tramways in both Karlsruhe and Heilbronn as well as main-line railway over its 150-km route from Achern to Öhringen.

But it is perhaps surprising that not more schemes modelled on this apparently thriving example have come to fruition, even in continental Europe. Those that are operational include Saarbrücken in Germany and the Rijn-Gouwe-Lijn through Leiden and Gouda in the Netherlands, with the French city of Mulhouse at the initial stages. An overview of these projects reveals that a certain number of factors typically have to come together for a scheme to work:

- a common tram and heavy rail track gauge and a suitable interface point between heavy rail and tramway;
- a relatively large but dispersed population, ideally with a strong commuting market – Karlsruhe, for instance, serves 120 communities with a total population of 1.3million people;
- favourable urban planning and public transport characteristics – the two must be considered together;
- existing heavy rail stations some distance from the main centres they seek to serve;
- an ability to overcome the technological challenges such as providing trams with two sorts of traction equipment, signalling compatibility, and meeting the relevant safety standards;
- perhaps most importantly, the political will and funding to see the project through.

Latest developments

One city where the balance of factors has been positive, however, is the city of Kassel in central Germany, which is currently developing its own 'RegioTram' system, due to open in June this year. A total network of 122km is provided with only 10km of new track, serving an urban population of 220,000 with a further 400,000 in the surrounding area. Although the system is based on the 'classic' tram-train principle with dual-voltage trams running on the mainline at 15kV AC and on the city tramway at 600V DC, one very significant innovation is the introduction of diesel trams for operation over non-electrified sections of line. This extends their reach beyond conventional electrified routes to rural single-track branches and diesel freight-only lines. Specifically, these vehicles are diesel hybrids: equipped with a diesel-electric engine, they are also able to work on the city tram network at 600V DC.

Each branch will operate to a regular interval 30-minute frequency, with connecting buses at stations along the route in line with the Taktfahrplan principle of bus and rail integration. Coupled with the enhanced journey opportunities, passenger demand on the network is predicted to grow by up to 50%.

Value for money

The total cost of the whole scheme is Euro 180million (£120million), made up of Euro 100million (£67million) for infrastructure and Euro 80million (£53milion) for new vehicles.

85% of the costs were borne by the Bundesland and federal government, with the remaining 15% contributed by the municipal authorities.

Key to the tram-train principle, and to the Kassel plan in particular, is maximum use of existing infrastructure to achieve greatest efficiencies and benefits. Diesel trams help to meet that goal by having the ability to fill in the electrification gaps as 'go-anywhere' vehicles, but the decision to choose them came about for three major reasons.

- Large infrastructure costs were avoided: the loading gauge in Zierenberg tunnel on the non-electrified Wolfhagen route to the west of Kassel did not allow for electrification without substantial rebuilding. This resulted in a capital cost saving of Euro 7.5million (£4.9million).
- In addition to the costs of rebuilding the tunnel, the capital spend to electrify the 30-km Wolfhagen route would have been around Euro 2million (£1.3million) per kilometre, not including ongoing operational expenditure, and unjustifiable in this case.
- Time and money would be saved in the planning process.

The above savings on the Wolfhagen route represent upwards of 55% of the total infrastructure costs of the entire project, and demonstrate, how much more expensive a fully electric system would be. Feasibility studies carried out between 2000 and 2003 focusing on whether to opt for electric-only vehicles or a mixed fleet containing diesel-hybrid versions as well, favoured the latter and resulted in the authority to proceed.

As an additional benefit, a short unelectrified freight-only chord at Kaufungen on the otherwise electrified Hessisch Lichtenau route could be brought into use to save eight minutes on the normal end-to-end journey time without any significant infrastructure work – an easy 'quick win'.

Comparison of diesel-hybrid and electric-only trams

	Diesel-hybrid tram	Dual-voltage electric-only tram
Number of vehicles	10	18
Power rating	600kW	600kW
Propulsion	diesel-electric: two roof-mounted six-cylinder MAN diesel engines, each delivering 375 kW tramway: 600 V DC	mainline: 15 kV AC tramway: 600 V DC
Number of traction motors	4	4
Acceleration from start	$1.1ms^2$	$1.1ms^2$
Maximum speed	100km/h	100km/h
Weight of a three-vehicle unit (when empty)	63.4t	59.8t
Weight of a three-vehicle unit (fully loaded)	85.2t	82.5t
Seating capacity	84 (plus 6 'tip-up')	84 (plus 6 'tip-up')
Standing capacity	139	139
Boarding height	360mm	360mm
Length over buffers / couplings	36.76m / 37.48m	36.76m / 37.48m
Width at maximum point	2.65m	2.65m
Minimum radius	22m	22m

Technical specification

Twenty-eight three-car vehicles were ordered for the project, 18 electric-only and 10 diesel hybrids. Built by Alstom, they are part of the Regio Citadis family. Both versions are visually very similar, and share many features for ease of maintenance. Crucially, performance is the same for both electric-only and diesel-hybrid vehicles – acceleration from start is $1.1ms^2$ in each case. A comparison of the vehicles is given in the table.

Transferability / applicability to UK

As stated above, conditions for tram-train have to be right, and given the small number of tram systems in the UK, let alone other complexities in the development of a scheme, it is clear that imitating the Karlsruhe model here is a harder task. The Sunderland extension of the Tyne & Wear Metro used some tram-train principles but employed the existing electric Metro vehicles, and areas including Greater Manchester and Teesside have been looking at the use of tram-trains. It would seem that in the UK context, diesel tram technology could help broaden tram-train's appeal, especially in increasing the affordability of light rail schemes, and where funding has been withdrawn owing to cost overruns as in the Leeds Supertram project. Potentially they combine the speed of a railway and the accessibility of a tramway, at a much lower capital cost than electric trams.

Joining up urban centres

First, taking advantage of a tram's ability to penetrate the urban centre, a tramway spur from the mainline to such 'honey pot' sites offers the opportunity to go right to where the customers want to go and encourage modal shift with seamless journeys. If Karlsruhe has shown that through journeys work with electric vehicles, then diesel trams prove that a potential station crucially need not be sited on an electrified Network Rail line – thus opening up the entire British railway network – nor would the tramway itself require electrification.

Blackpool illustrates the potential: diesel trams offer the prospect of linking up the South Fylde line with the tramway, thereby opening up many new journey opportunities and contributing to the area's regeneration. As no electrification would be necessary, major new infrastructure would be confined to connecting the two networks and restoring some of the double track on the railway section. There are also knock-on benefits to the local service: faster, more frequent

The diesel tram idea could be a low-cost alternative for branch lines such St Erth to St Ives, seen here. This is No 153329, which was released to traffic painted in a St Ives Bay livery and named *St Ives Belle* in a ceremony at St Ives. The vehicle is seen approaching Carbis Bay on its way to St Ives on the naming day, 4 December 2005.
Colin J. Marsden

The village of Weimar near Kassel, where light rail and heavy rail share tracks. On the left is a diesel-hybrid tram, on the right is a Stadler GTW DMU of the Kurhessen Bahn. *Heribert Menzel*

Kassel tram-train network

journeys and reduced wear and tear on the track thanks to tram running characteristics and lighter axle loads.

Again, this has been demonstrated in Kassel where the 30-km predominantly rural line to Wolfhagen has a mixture of stopping and semi-fast services, taking between 47 and 33 minutes to Kassel. Operating a diesel tram on the stopping services with its superior acceleration and braking performance has allowed five new stations to be served whilst maintaining existing end-to-end schedules. Conventional trains can then be more usefully deployed on semi-fast services.

Challenges

As in Kassel, electrification could be employed where it is essential, for instance in city centres and particularly sensitive areas, with diesel operation along converted local train routes or more open corridors. The same might be envisaged in Nottingham for example, with through services from Mansfield using a link at Bulwell to access the city centre.

It is also conceivable that diesel trams could be used on a self-contained tramway where costs are reduced through not having to electrify from the outset. Given our acceptance of buses in city centres, why are we not ready to tolerate diesel tram operation? Personal experience has shown a diesel tram to be perfectly acceptable: it is far quieter and has less visible emissions than any of the diesel trains operating in the UK. Queues of idling buses waiting in Manchester's Piccadilly Gardens, London's Oxford Street or any of the other increasingly congested UK cities underline the fact that all modes of transport are polluting. A central issue for debate, therefore, is where it is acceptable for that pollution to be produced: at the point of use as with diesel traction, or confined to a power station. Ever more sophisticated diesel engine technology and cleaner fuels such as Ultra-Low Sulphur Diesel mean that a modern diesel vehicle is coming ever closer to meeting the environmental acceptability standards of an electric.

Operational flexibility

The attraction of diesel trams does not merely lie in their ability to operate as urban street vehicles. With regard to rolling stock operation, in a climate where everything must be increasingly accountable, does it always make sense to run conventional trains on rural routes or a small shuttle service? Running a diesel tram over the St Erth – St Ives or Marks Tey – Sudbury branch, for example, could result in lower infrastructure operating and maintenance costs, as well as freeing up the conventional DMU for use elsewhere. A diesel tram-style service could also allow extra stops to be served, as suggested for the Tees Valley for instance (p50, last month). If more capacity is needed, several units can be coupled together (up to four can run as a 'train' in Kassel). Of course, the ultimate is full conversion of the line to tramway standards with simplification or even removal of signalling – driving on 'line of sight' – and again lowering track maintenance costs. Retaining the option of through running onto the mainline would open up many more possibilities, and also allow access to existing maintenance facilities elsewhere on the network if required.

The future

There are signs that the industry is looking towards an approach where operational and maintenance standards on a line are more closely dictated by its function and the type of traffic it sustains. We must be ready to accommodate this shift in focus if it secures the longer-term future of more lightly used lines and ensures they remain fit for purpose. Community railways are a prime example of this: if a certain route with a low line speed only sees a few passenger trains a day operated by Pacers and no freight, why could this service not be provided by a diesel tram with its attendant cost savings and, from the passengers' perspective, a more comfortable journey experience?

Diesel trams will not provide the answer in all cases, but they have clearly helped to provide new impetus to the tram-train concept as well as demonstrating their value as rail vehicles in their own right. At a time when the train-infrastructure interface comes under closer scrutiny, considerably lighter tram-type vehicles could contribute to a 'virtuous maintenance circle', and Network Rail's vision for a more reliable railway. In the effort to maintain and grow rail's attractiveness through 'joined-up journeys', and to ensure that each line is used as appropriately as possible, light rail technologies are likely to play an increasingly important role. Diesel trams are well placed to form part of that mix. **MR**

Following a year's internship in Germany with DB (German Rail) and a transport planning consultancy, Charles King joined the Transportation Division of Faber Maunsell as a rail transport planner. Last year, on behalf of ACoRP, he organised the tram-train study visit to Switzerland and Germany referred to in this article.

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Alstom to test onboard flywheel energy storage

18 January 2013

ENERGY: Alstom Transport and Williams Hybrid Power signed an agreement on January 17 to test Williams' energy storage technology on a Citadis tram.

Under the exclusive relationship, the two companies will adapt Williams' composite MLC flywheel energy storage. Trials will start in 2014, with a view to installing a prototype system on an existing vehicle by the end of that year.

Williams' flywheel technology was originally developed for the 2009 Williams Formula One car, and has since been introduced into London buses. It offers fuel savings of up to 15% by recovering braking energy that is normally lost as heat. The rotor flywheel is made from a composite material, which makes it safer than metal at high speeds.

Related News:

- European Commission backs regenerative braking R&D - 04.12.12
- Supercapacitor light metro train unveiled - 23.08.12
- Genève tram trial assesses supercapacitor performance - 07.08.12
- Supercapacitor energy storage for South Island Line - 03.08.12
- DMUs to test regenerative braking - 18.06.12
- Energy storage offers Macau metro 10% saving - 15.06.12
- Hydrogen fuel cell tram unveiled - 19.10.11
- Flywheel railcar to operate demonstration commuter service - 14.01.11
- Fuel cell tram trial - 24.06.10

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ALSTOM

CITADIS DUALIS

COMBINING THE BEST OF TRAINS AND TRAMWAYS

*We are shaping the future** ALSTOM

CITADIS DUALIS

Optimized access for all
With its full low floor and wide gangways, Citadis Dualis is the first tram-train vehicle certified according to STI PRM* standards.

Passenger comfort
Citadis Dualis offers many options dedicated to passenger comfort, depending on the profile of the line served. Among the possibilities are toilets, more comfortable seats, window shades and umbrella racks…
Citadis Dualis makes on-board comfort a priority.

Operating tools
Citadis Dualis also offers anti-vandalism and passenger-counting options to optimize public transit operations for maximum vehicle availability.

Modular Design
Citadis Dualis may be configured to the needs of each operator.
Urban or peri-urban configuration, number of doors per side, interior spaces… the design and layout of your Citadis Dualis are modular to fit the type of itinerary.

* Excluding the toilet option

4 **DEGREES** OF FREEDOM

LENGTH

42 Meters and 52 Meters

WIDTH

2.4 Meters and 2.65 Meters

ELECTRIC POWER SUPPLY

Dual voltage 750 Vdc / 25 KVac 50 Hz
Or dual voltage 750 Vdc / 1500 Vdc

INTERIOR FITTINGS

- Length: 42 m
- Width: 2.4 m
- 4 doors
- 93 seated places
- 141 standing places

- Length: 42 m
- Width: 2.65 m
- 4 doors
- 98 seated places
- 153 standing places

- Length: 42 m
- Width: 2.65 m
- 5 doors
- 92 seated places
- 159 standing places

- Length: 51.5 m
- Width: 2.4 m
- 6 doors
- 116 seated places
- 176 standing places

2.4 meters

2.65 meters

CAPACITIES

	VERSION 2.65 M 4 CARS 4 DOORS	VERSION 2.65 m 4 CARS 5 DOORS	VERSION 2.40 m 4 CARS 4 DOORS	VERSION 2.40 m 5 CARS 6 DOORS
Seats + Tip-up seats CE2 C2 CE2B C1 CE1	18 + 2 32 24 + 2 18 + 2	18 + 2 32 20 18 + 2	16 + 2 32 22 + 3 16 + 2	16 + 2 20 40 20 16 + 2
Total	92 + 6	88 + 4	86 + 7	112 + 4
Passenger in Wheelchair space Bicycle rack Luggage rack	2 1 1	2 0 0	2 1 1	2 0 0
Total passengers 4 persons/m² 6 persons/m² 8 persons/m²	251 330 410	251 332 414	234 307 381	292 382 472

TECHNICAL **SPECIFICATIONS**

Type	Articulated – 4 to 5 car bodies
Length	4 car bodies: 42 m 5 car bodies : 52m
Width	2.65 m (4 car bodies) or 2.40 m (4 or 5 car bodies)
Height	3.5 m
Floor height (4 pers/m^2 + seats folded, new wheels) • Access (gap-filler) • Corridor central part • Corridor above bogies	 370 mm 405 mm 537 mm
Multiple Unit	Up to 3 units (MU3) with 4 car bodies
Structure • Compression • Passive safety	 600 kN complies with standards EN12663 and EN15227
Performance • Maximum speed • Maximum acceleration from start up	 100 km/h 1,09 m/s^2 from 0 to 40 km /h (base version)
Braking • Types • Maximum Emergency braking deceleration	Electric, Electrohydraulic and Electromagnetic 2.8 m/s speed ≤ 70 km/h 2.5 m/s speed > 70 km/h
Weight • Tare weight • Maximum load per axle (6 persons/m2 + seats extended)	 ≈77 t (4- car vehicule) 11.5 t
Traction • Type • Continuous Motor power	 IGBT, 3-phase permanent magnet synchronous motor Motor 6 x 150 kW
Train Control / Command	Redundant MVB network / WTB Cabled commands for safety functions
Electric power supply	Dual voltage 750 Vdc / 25 kVac 50 Hz Dual voltage 750 Vdc / 1500 Vdc
Auxiliary power	400 Vac /50 Hz 24 Vdc
Minimum curve radius	25 m
Capacity in EL4 (4 pas/m^2) • 4-car vehicle • 5-car vehicle	Fixed seats / Total 86-92 / 234-251 112 / 292
Corridor width	600 mm (2.65 m version)
Passenger access width	Double sliding door / 1,300 mm passage
Platform access	Fill-gap
Passenger Information • Base • Option	 Interior and exterior LED display screens + audio TFT screens

OPTIONS

DESIGN OPTIONS	Length (in m.)	42	42	42	52
	Width (in m.)	2,65	2,65	2,4	2,4
	Number of cars	4	4	4	5
	Number of doors per side	4	5	4	6
	Luggage space	●	●	●	●
	Bicycle space	●	●	●	●
	Retractable steps	●	●	●	●
	Maximum number of doors per side	5	5	5	7
CONTRACTUAL OPTIONS	Toilets	●			
	Fixed steps for the doors	●	●	●	●
	Supply and installation of passenger-counting system	●	●	●	●
	Lengthwise umbrella rack	●		●	
	Exterior livery	●	●	●	●
	Trash receptacles	●	●	●	●
	Passenger window shade	●	●	●	●
	More comfortable seats (cannot be combined with anti-vandalism option)	●			
	Anti-vandalism (cannot be combined with more comfortable seat option)	●			

COMFORT **OPTIONS**

TOILET OPTION*

The toilet option* is offered aboard the CITADIS DUALIS in a suburban configuration (2 m65 in width) in order to improve passenger comfort for trips that exceed 30 minutes. This is a unique option in a tramway-type LRV. Two variants are possible for this option:

- Factory-fitted toilets,
- Preparation for toilet integration at a later time (for example in the case of a line extension)

* Option non-certified STI PRM

LENGTHWISE UMBRELLA RACK OPTION

CITADIS DUALIS can also be equipped with lengthwise overhead racks. These allow passengers to put small objects, umbrellas, jackets... above their seats and also improve passenger comfort in freeing up space.

TRASH RECEPTACLE OPTION

Trash receptacles can be installed as an option aboard the CITADIS DUALIS. They facilitate maintaining a high level of on-board cleanliness, improving both the trip's ambiance and the cleaning work.

PASSENGER WINDOW SHADE OPTION

Passengers are able to adjust sunlight to what's comfortable.

MORE COMFORTABLE SEAT OPTION (CANNOT BE COMBINED WITH THE ANTI-VANDALISM OPTION)

Improved seating and an added headrest offer passengers greater travel comfort.

TECHNICAL **OPTIONS**

FIXED STEPS OPTION

Removal of the retractable steps (standard edition) in order to reduce passenger exchange times at stations.
This option requires an appropriate infrastructure.

PASSENGER COUNTING OPTION

All vehicle accesses are equipped with a system that makes it possible to note passengers getting on and off.
The number of passengers aboard is thus known at all times.
This is an essential element for tram-train operations.

INDIVIDUALIZED EXTERIOR LIVERY

To facilitate its integration in the regional landscape, the livery of the CITADIS DUALIS can be individualized with the colors of the region.

ANTI-VANDALISM OPTION

CITADIS DUALIS's anti-vandalism resistance can be reinforced with an interior and exterior film protection on the car.

BICYCLE SPACE / LUGGAGE SPACE (OPTION DEPENDS ON THE BODY CAR' DESIGN)

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Lyon tram-train service launched

25 September 2012

FRANCE: SNCF began operating tram-train services from Lyon Saint-Paul to Sain-Bel on September 24, following an official opening ceremony two days before.

On weekdays there is now a service every 30 min, increasing to every 15 min between Lyon and L'Arbresle during the peaks. It is hoped that ridership will double from present levels to 13 200 passengers a day by the end of 2012.

It is the first of three routes from Lyon Saint-Paul serving the city's western suburbs that are to be converted to tram-train operation. Subject to obtaining the necessary safety approvals, Alstom Citadis Dualis vehicles are expected to begin operating to Brignais in December, using a new east to south chord at Tassin, followed by the route to Lozanne.

Total cost of the infrastructure work required for the west Lyon tram-train programme is estimated at €150·2m, of which €91·4m is being provided by the Rhône-Alpes region, €16·5m by the French government and €15·9m by infrastructure authority RFF. The Greater Lyon authority has contributed €13·1m, the Rhône *département* €12·5m and SNCF €800 000.

Infrastructure work has comprised doubling some sections of single line, lengthening passing loops, track renewals, electrification and resignalling. Platforms have been rebuilt to provide level boarding, while a €35m station modernisation programme has included the installation of a real-time passenger information system and improved facilities for cyclists. A new station has been built at Lentilly-Charpenay, and Dommartin-Lissieu relocated; both now provide park and ride facilities.

Within a €650m framework agreement between SNCF and Alstom for up to 200 vehicles, a fleet of 24 Citadis Dualis tram-trains has been acquired for €100m, entirely funded by the Rhône-Alpes region. The 42 m long vehicles have 100 seats and can accommodate 150 standing passengers, with a maximum speed of 100 km/h.

Maintenance is undertaken at a new facility built on a 1·5 ha site near L'Arbresle station, funded by the Rhône-Alpes region (€11·48m) and SNCF (€3·82m).

Related News:

Electrification contract for Bordeaux tram-train project - 25.02.13
Alstom launches North American light rail vehicle with Ottawa contract - 14.02.13
T2 completes Dijon tram network - 18.12.12
Le Havre celebrates tramway opening - 12.12.12
Tours 'architecture in motion' tram unveiled - 02.10.12
UK must start developing tram-train now - 26.06.12

Tramwave on test

ITALY: Ansaldo STS is testing ground level power supply technology for street-running tram tracks, eliminating the need for overhead wires. Known as Tramwave, the equipment is undergoing live trials along a major thoroughfare in Napoli. More than 600 m long, the test section has allowed Ansaldo STS to monitor and analyse performance of the system under actual operating conditions with heavy road vehicles passing over it.

The test site forms part of a recently completed extension of the Emiciclo Poggioreale – Via Stadera tram route. It has attracted considerable interest, with numerous delegations from European and Asian countries visiting Napoli to see the system in action. Ansaldo STS has also used the site to obtain safety certification.

Ansaldo STS initially tested Tramwave on a 400 m elevated track located in its own factory premises in Napoli. Experience built up with this installation gave the company confidence to experiment with a live installation on a public road.

How it works

The design makes use of magnetic collector shoes attached to the tram bogies. The shoes are fitted with copper and graphite contact surfaces which pass over steel plates affixed to a modular box-shaped contact line laid between the running rails. The permanent hybrid magnets in the shoe lift a ferromagnetic belt housed in a continuous module located below the steel plates, where a 750 V DC conductor rail and an earthed contact are also enclosed.

Each element of the module is typically 3 m or 5 m long. The steel contact plates are each 500 mm long and are insulated from each other. As each portion of the belt is lifted by the magnets on the shoe, it touches the plate, allowing current to pass through to the tram's traction equipment.

Energy only passes through the plates when the collector shoe is present, and the supply line voltage returns to zero as soon as the tram has passed over each segment. The live section beneath each power collecting bogie is less than 2 m long.

Ansaldo STS sees a large market for the technology, not least because of the huge interest in tram projects in many countries, but also because many cities have areas of historical or architectural importance where a catenary-free tram line would appeal to planning authorities.

The company notes that requests for wire-free systems have come from Qatar and Dubai. It also says that interest has been shown by countries where the frequency and intensity of weather phenomena render overhead wires impractical, for example in Taiwan.

Tramwave is being tested on a 600 m test section in Napoli.

The AnsaldoBreda Sirio trams used to test Tramwave are fitted with an underfloor pick-up shoe.

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Rhein-Neckar Verkehr orders more supercapacitor trams

05 April 2011

GERMANY: Rhein-Neckar regional transport operator RNV has ordered a further 11 low-floor Variobahn trams for €33m, Bombardier Transportation announced on April 4.

They will be fitted with Bombardier's Mitrac Energy Saver technology, which uses roof-mounted double-layer supercapacitors to store electricity regenerated during braking for reuse when accelerating. Trials in Mannheim have demonstrated a reduction in energy consumption of up to 30% using Energy Saver, which is currently fitted to 19 RNV trams.

Delivery of the latest batch of air-conditioned and wheelchair-accessible cars is scheduled for January to June 2013. 'Starting in 2013, we will be operating entirely with modern, low-floor vehicles on the 200 km railway and tram network of RNV', said Martin in der Beek, Chief Technical Officer at RNV. 'Together with ongoing accessibility upgrades at stops in Ludwigshafen, Mannheim and Heidelberg as well as the surrounding area, we are contributing to the increasingly important concept of universally accessible public transport.'

The latest order is an option on a contract signed in 1998. The trams are to be built at Bombardier's Bautzen plant, with bogies from Siegen and electrical equipment from Mannheim.

Related News:

Supercapacitor light metro train unveiled - 23.08.12
Genève tram trial assesses supercapacitor performance - 07.08.12
Supercapacitor energy storage for South Island Line - 03.08.12
Dresden Messe tram extension opens - 02.06.11
First Stadler Variobahn arrives in Potsdam - 31.05.11
Supercapacitors to be tested on Paris STEEM tram - 08.07.09
Primove catenary-free induction tram - 23.01.09
Ultracapacitors on test - 08.01.09
SuperCap tests complete - 18.03.08
UltraCaps win out in energy storage - 01.07.06

Links:

Rhein-Neckar-Verkehr

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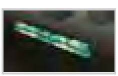

PRIMOVE: Game-changing turnkey solution for tram systems

More information

German Federal Ministry for Transport, Building and Urban Development (BMVBS)

Augsburg Transport Authority (STAWA)

Tüv Süd

Catenary-free operations for trams

In September 2010, Bombardier Transportation installed the contactless and catenary-free PRIMOVE system for trams on a 800-metre section of Line 3 on the Augsburg trade fair centre. The pilot project is co-funded by the German Federal Ministry for Transport, Building and Urban Development (BMVBS) and realised in cooperation with the Augsburg Transport Authority (Stadtwerke Augsburg Verkehrs GmbH) with the aim of demonstrating reliable operation under the real conditions of daily operation in an urban environment.

Bundesministerium für Verkehr, Bau und Stadtentwicklung   swa Stadtwerke Augsburg

Demonstrating safe high power inductive charging for trams

Phase 1: Winter 2010 – Fall 2011

One Bombardier bidirectional low-floor tram was fitted with two PRIMOVE power receivers (pick-up coils) to capture the inductive power that is transferred from eight-metre cable segments laid between the rails underneath the ground. Inverters along the track wayside are connected to a 750 Vdc power supply network.

Once supplied with energy, the cables create a magnetic field that is sensed by the tram's pick-up coils and turned into an electric current that propels the tram. Segments not covered by the tram are not activated.

Energy storage solution for added energy efficiency
Two energy storage devices were also mounted on the tram roof. Every time the vehicle brakes are applied, super capacitors store the released energy for later use. When installed on light rail vehicles, the system reduces energy consumption by 30%, thereby significantly minimising electricity costs.

Phase 2: Fall 2011 – Summer 2012
In the second phase of the project, a PRIMOVE-equipped bus and minivan will undergo tests to demonstrate the intermodality of the system. Multimodal charging compatibility has already been demonstrated with a PRIMOVE-equipped road vehicle that recharged using the same charging infrastructure installed for the tram. Further tests will continue until the end of the summer 2012.

May 31, 2012: PRIMOVE international media event and world premiere of inductive technology
Bombardier welcomed more than 80 international journalists and guests to the world premiere of inductive technology for all e-vehicles at the PRIMOVE test track in Augsburg.

To download the press release, please click here.

To view the video, please click here.